Mobile Augmented Note-taking to Support Operating Physical Devices

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Abstract
In this paper we propose an approach to assist operating physical devices with mobile augmented reality techniques. We propose ideas of interaction techniques, which allow users to put self-authored information as notes onto physical objects. We present the design of two example applications aiming at solving problems from different aspects of physical operations.

Keywords
Mobile augmented reality, physical operation, note-taking, AR authoring

ACM Classification Keywords
H5.1. Multimedia Information Systems: Artificial, augmented, and virtual realities. H5.2. User Interfaces.

Introduction
When interacting with appliances, we often need instructions about which component to manipulate and how to manipulate it: "How to set the timer of my new oven? What is the code to enter the building of my friend Mat?" Such systems often come with written instructions provided by the manufacturer. But these instructions must be accessible during the interaction and are sometimes difficult to retrieve or even

unavailable. Furthermore, these ”user manuals” are made for all users, and do not provide solutions for problems that are specific to a certain user, neither do they capture personal experience of the user while interacting with the system.

Such personal instructions or notes can be recorded as text, pictures, audio, or video with mobile devices, suitable for taking and retrieving notes anywhere [7]. However, several problems arise when recording personalized instructions about physical interaction:

- Information from text has to be interpreted and mapped to the physical objects.
- Pictures give snapshots of several states of the system, but do not capture the dynamic aspects of the interaction.
- It is time-consuming to find the right information along the timeline in video or audio notes.
- Images, audio and video are not directly editable.

To address these issues, we investigate how mobile augmented reality can be used to record and present personal instructions to assist physical interaction. Augmented reality maps digital information to physical objects. It can save significant effort when searching for objects, and enables a dynamic and editable visualization for guidance of the operation.

Related Work

Augmented Reality for Physical Operations

Several AR systems to assist physical operations have been proposed. In [4], Motokawa et al. present a system that shows a virtual hand over a video of the user while he is playing guitar. Billinghurst et al. [1] propose a step-by-step task guide for a complex machine: users take a picture of a part of the machine on a mobile phone which then displays simple animations of the possible operations for that part. The Augmented Anesthesia Machine [5] helps students interacting with an anesthesia machine by displaying animations on a position-tracked tablet that presents how the performed operation affects internal components and gas flows.

However, none of these systems allow users to place self-created instructions over the objects. Users are seldom the creator, editor and manager of the overlaid information.

Augmented Reality with User-Created Content

ButterflyNet [8] combines mobile AR and note taking in an augmented notebook that allows to link handwritten notes to multimedia files. With Spyn [6], users can create virtual pins on a scarf while knitting, and associate them with video recordings of memorable events or sights during the knitting process.

Such systems that allow users to link self-created content to physical objects can be used to assist operating physical devices. However, as pointed out in the introduction, text, pictures and video have some limitations in this context .

Augmented Reality Authoring Systems

Guven et al. [2] propose a system that allows freezing and editing the current AR scene displayed on a tablet, which acts as a Magic Lens for the real environment. Designers can annotate the environment with text labels and associate audio snippets to locations on the scene. Sketching Up the World [3] introduces an interface for creating AR content, such as virtual duplicates of real world objects with 3D models and 2D sketches. Their goal is to enable users to become the content creators.

While we may benefit from some aspects of this existing work, AR authoring systems primarily aim at providing easy ways for designers to create and edit AR content, which is a different problem domain from the one we are examining.

Design Approach

Our design allows end-users to easily create and retrieve AR instructions for physical operations with a mobile device. These instructions are presented in an AR layer linked to physical objects. Unlike other formats, such as video, this approach provides a rich visualization with real-time localization of the digital information shown on top of physical objects.

With our approach, users can create their own instruction resources for specific problems everywhere and review them directly in the context of use. Unlike other AR authoring systems, we are not exploring the authoring capability depending on tracking and modeling. Instead, we want to explore how AR authoring and visualization techniques, applied to note taking, can support operating physical devices.

Design of Example Applications

Two simple applications illustrate this concept in different scenarios.

Keypad Reminder

Figure 1. AR layer for passcode entry: the user "scans" a keypad with a camera phone; once the keypad is recognized, the phone displays animated tapping footprints between the keys to illustrate the required key sequence (passcode) for unlocking the door.

In Paris, it is common to have keypads to unlock the front doors of apartment buildings, and people are commonly stuck in front of such a keypad, because they have forgotten the code or lost the note with it. Furthermore, the variety of keypads with different keys and layouts makes it hard to remember the code and to input it. Figure 1 shows how this problem can be solved with our approach. The instructions are automatically generated from the code and support the code entry especially on custom keyboard layouts through the dynamic visualization displayed on top of the physical counterpart.

Figure 2. Displaying AR notes on a guitar amplifier for different settings with different zoom levels.

Guitar amplifier assistant

Dynamic visualization is just one of the advantages of associating AR layers with physical objects. Another advantage is that AR notes can ease the storage, organization, and visualization of configuration settings of physical panels or machines.

Figure 2 shows how editable AR layers can be used to augment a guitar amplifier and store different configurations. The AR layer naturally sticks to the physical object on the screen of the mobile device, showing an overview of all settings when the device is held far away or a detailed description when the device is moved closely. Better than browsing multiple photos, this approach provides a continuous experience, where it is easier for the user to find certain controls.

Challenges and Opportunities

Designing a system for users to become creators of AR content comes with interesting challenges:

- The richer the visualization, the more input is needed from the users, who are limited by the inherently difficult input modalities of mobile devices. How can we make the authoring of AR notes easy and efficient enough to be feasible?
- It is common to organize and share notes. Because AR notes are connected to physical objects, the sharing and organization of AR notes is different from regular notes. What are appropriate techniques for organizing and sharing AR notes?
- Rapidly improving sensing technology enables users to define specific components to be recognized by the device. Therefore, our approach could be generalized to many operation tasks that consist of configurations and simple movements.

Conclusion

This work is still at an early stage. We identify a research area in Mobile AR in the context of AR authoring and operating physical devices, which has not been explored thoroughly. The example applications demonstrate the idea of how augmented note taking can assist physical operations.

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